

25X1  
Approved For Release 2009/02/18 : CIA-RDP80T00246A006500390002-6

**Page Denied**

Next 1 Page(s) In Document Denied

Approved For Release 2009/02/18 : CIA-RDP80T00246A006500390002-6

## DIAGNOSTIC PROPERTIES OF THE PROCESSES OF FORMATION OF BITUMENS, PETROLEUM AND GAS

By I.O.Brod

When estimating oil and gas possibilities of the large territories, simultaneously with countouring of closed down-warped areas of the earth's crust which may be considered as oil and gas basins, a task should be undertaken to segregate in stratigraphic sequence all possible regionally productive series. Among the latter not all can be considered as singene-tic productive series. In order to prove the formation of pet-roleum at the expense of source material contained in sediments of the same series, it is necessary to ascertain genetic affi-nity of this material with liquid and gaseous hydrocarbons composing the pools. Regular relationship of oil and gas accu-mulations within the large territories to certain lithological stratigraphic complexes has been ascertained as far back as the last century. At that time it has been suggested that oil and gas were formed in reservoir beds at the expense of hydro-carbons educing from dark-coloured pelite rocks where they we-re in a dispersed state.

The study of regional petroliferous Miocene series conducted in 1925-1927 in Northern Caucasus by A.D.Arkhangel-sky provided a possibility to formulate a concept of source rocks or oil producing rocks. In the first stage of study of pelite rocks considered as source rocks only the quantity of

---

x) Professor of the Moscow State University, D.Sc.

- 2 -

carbon dispersed therein has been determined. It has been assumed that organic carbon is represented generally by bituminous substances consisting of hydrocarbons kindred to oils and forming pools in reservoir beds of the same series. But, in point of fact, it has been ascertained shortly after that organic matter dispersed among mineral particles of pelite rocks is represented in the main by coaly compounds. Thus grounds have appeared for denial of genetic relationship between dispersed organic matter and oils.

In 1947-1950 in the Forecaucasus the Department of Geology and Geochemistry of Gnostobioliths of the Moscow State University has widely adopted luminescence-bituminological investigations with a view of comparing the composition of organic matter dispersed in Mesozoic and Tertiary deposits with the oils of the same series. These investigations have proved that in the bulk of dispersed organic matter kindred to oil bituminous substances kindred to petroleum are always present. Further researches have shown that bituminous substances are more often represented by asphaltites, resins and oils. The quantity and ratio of the above components are different in various rocks. On the basis of study of regularities in the occurrence of dispersed bitumens a conclusion has been drawn that a differentiation of dispersed bitumens exists in rock series and that it depends on their lithological composition. The lighter components represented by oils are educing in various kinds of pelite rocks enriched by alcurite and sandy particles. In case reservoir beds are available in pelite rocks containing dispersed bitumens, the greatest quantity of components consisting mostly of hydrocarbons is discovered in these beds.

- 3 -

The conclusions arrived at have been confirmed and extensively developed as a result of investigations conducted in the Forecaucasus by VNIGRI and CHOSK of the Academy of Science of the USSR, as well as by the Institute of Petroleum of the Academy of Science of the USSR, Institute of Geology of the Academy of Science of the Azerbaijan SSR, VNIGRI and by other organizations in various parts of the country. It has been ascertained that all argillaceous and shale-alcurite rocks formed in reducing environment, both carbonate and non-carbonate, contain always bitumens kindred to petroleum, but usually in considerably lesser quantity than that of coaly substances dispersed among mineral particles of pelite rocks. The presence of bituminous substances kindred to petroleum has been ascertained also by VNIGRI when studying recent sediments.

Until recently a doubt has been casted on chemical affinity between bituminous substances determined by luminescence analysis and oils. This problem has found a positive solution after a study of bituminous substances extracted from subcapillary pores of pelite rocks in the chemical laboratory of the Department of Geology and Geochemistry of Conastobioliths of the Moscow State University.

At present many petroleum geologists adhere to the erroneous idea that such mobile substances as water and bitumens are present in the rocks either in a free state which permits their migration according to the law of gravity, or in a bounded state absolutely barring any migration. It is known that freely migrating mobile substances are contained in sporecapillary pores of the rocks, while bounded mobile substances either

- 4 -

envelop every mineral particle of the rock or are contained in their crystalline lattice. Besides the above two states there exists a third one, viz. semi-bounded or faintly-bounded state of mobile substances saturating subcapillary pores.

The migration of water in semi-bounded state at the time of compacting of plastic argillaceous-alaurite and marly rocks has been ascertained long ago. As far as bituminous substances is concerned, the process of their molecular migration in subcapillary pores has been formulated by us in 1946-1947 when working out a classification of migration processes. At the same time it has been suggested that bituminous substances migrating in subcapillary pores together with water are transformed into petroleum only at the time of their transition from semi-bounded into a free state. Such transition in laboratory conditions is accomplished during extraction of bitumens from subcapillary pores by means of solvents. In the nature this process occurs during transition of bituminous substances from subcapillary pores into supercapillary pores and fissures within one and same series of sediments as well as from one series to another. Petroleum originates at the expense of such transition on stratification planes and in fissures of clayey sediments containing bitumens in subcapillary pores. Identical process takes place also during transition of mobile substances from subcapillary pores of poorly permeable rocks into reservoir beds.

The process of molecular migration is considered by us as a series of complex physico-chemical transformations undergone by mobile substances during their migration in a semi-bounded state in subcapillary pores of argillaceous, marly and argillaceous-alaurite rocks which started to compact. The process of

- 5 -

molecular migration accompanied by physico-chemical transformations of mobile substances in subcapillary pores continues the full length of rock compacting up to their complete lithification, viz. until the rocks lose their plastic property. The process of bitumen formation at the expense of dissociation of organic matter dispersed among mineral particles of the rocks takes place precisely during this stage.

The idea of bitumen formation as a process accompanying dissociation and gradual metamorphism of the organic matter dispersed in argillaceous-aleurite rocks at the time of their compacting has been expressed by us for the first time in 1953-1955. Later on the principal features of the process of dissociation have been formulated. This process consists, on the one part, in transformation of coaly particles on the way from lignites to coal and then to anthracites and graphites and, on the other part, in educing new portions of bitumens consisting at the beginning of mixtures of highly molecular substances - asphaltines, resins and heavy oils and then of mixtures of various oils and at last of methane only.

To-day the dissociation of organic matter during lithification and metamorphism of argillaceous-aleurite rocks is proved by investigations of various organizations. Many scientists have no doubt as to the existence of process of continuous bitumen formation accompanying dissociation of organic matter.

The above mentioned scheme of bitumen formation provides a possibility to look for regular relations between compacting intensity of argillaceous-aleurite rocks and quality of bituminous substances dispersed therein. The study of qualitative composition of dispersed bitumens may prove to be rather fruitful

- 6 -

for prognoses concerning composition of oils and gases forming the pools fed by bitumens dispersed in argillaceous-aleurite rocks.

Thus, the ways are traceable for bringing into practical use the results of lithological-bituminological study of the rocks with a view of revealing not only the processes of bitumen formation, but also those of oil and gas formation.

Proceeding from the above, it is apparent that the rocks possessing subcapillary pores are in the main bituminiferous (bitumen generating rocks). But the process of oil and gas formation may take place only in case when bituminous substances from a dispersed state in subcapillary pores migrate into a free state in supercapillary pores of reservoir beds, where at the time of educing from water they form oil and gas pools. These processes proceed somewhat differently in such carbonate rocks as limestones and dolomites, lithification of which is accomplished very fast.

The geological and geochemical properties of the rocks, for which the process of disassociation of organic matter with formation of dispersed bitumens may be ascertained, are considered in the enclosed table first of all. With this purpose the results of study of Mesozoic and Tertiary sediments of the Forecaucasia have been used in the first instance and all available data on other areas have been considered. The table shows that only rocks formed in the conditions of predominated downwarping of subaqueous fine-grained both carbonate and non-carbonate sediments may appear as bituminiferous (bitumen generating rocks). Precisely these features determine the presence of reducing environment in the process of sedimentation and during all subsequent transformations. The colour of these rocks is gray, bluish or

- 7 -

pale-bluish, sometimes with brown or green tint. It is characteristic to note that on account of this colouring, even among thick series of red-coloured rocks, the rock series in which bitumen formation could have taken place are easily detectable. But at the same time it is apparent that bitumen formation takes place only in case when among mineral particles there are in a dispersed state organic substances supplying in the process of dissociation both coaly and bituminous compounds. It may be assumed that gradual compacting of pelite rocks provoked metamorphism of coaly substance and simultaneously formation of bitumens according to the above mentioned scheme. The bituminous substances educing in the process of dissociation accomplish all their further transformations together with faintly-bounded water contained in subcapillary pores. Consequently, the compacting of sediments resulting in lithification and provoking the closing of subcapillary pores may serve as a certain indication of slowing down and discontinuance of the process of bitumen formation. The process of bitumen formation may start again only at the expense of dissociation of free bitumens which educed during lithification and filled up fissures and vugs. Such a process is observed apparently in bituminous limestones and dolomites characterised by abundant inclusions of asphaltites in fissures and vugs. It is possible to extract bounded bitumens from carbonate rocks only after their complete destruction. Consequently, the process of bitumen formation in carbonate rocks practically ceases with their lithification. At the same time free bitumens which educed in the form of asphaltites and filled up micro-and-macro fissures, vugs and all other cavities may supply at the expense of dissociation new



- 8 -

portions of mobile bituminous substances. Series of such bituminous limestones of upper Jurassic and lower Cretaceous are extended on the Northern slope of the Caucasus for several kilometres. In the Western part of East Siberian platform thick series of lower Paleozoic bituminous limestones and dolomites containing huge asphaltite inclusions occur still more widely. The study of asphaltite inclusions in schlyfs under ultra-violet microscope shows the presence around them of halos consisting of mobile bituminous components. Therefore, it is not excluded that the dissociation of asphaltites may lead to the formation of hydrocarbons kindred to petroleum. Consequently, it is very likely that the formation of bitumens at the expense of dissociation of asphaltites can be connected with lithified carbonate rocks - limestones and dolomites. In case this process is confirmed by further investigations, bituminous limestones and dolomites containing in the cavities asphaltites inclusions could be considered as bituminiferous (bitumen generating rocks).

Thus, if the formation of bitumens in poorly permeable argillaceous and argillaceous-alcorite rocks proceeds at the expense of dissociation of dispersed organic matter with transformation of bitumens in subcapillary pores, the dissociation of free bitumens - asphaltites contained in supercapillary pores apparently takes place in lithified carbonate rocks.

The bitumen formation is an intermediate process on the way to formation of oil and gas. For the process of oil and gas formation it is insufficient to have initial bitumens. Favourable conditions permitting petroleum hydrocarbons to evolve from dispersed bituminous substances are also necessary.

It is shown in the lower part of the table that the for-

- 9 -

mation of oil and gas takes place only at the time of transition of hydrocarbon part of bitumens into reservoir beds. This process can proceed in the same series in which bitumen formation takes place as well as in series deprived of bitumen generating rocks.

Only those terrigenous and carbonate-terrigenous series in sequence of which bitumen generating rocks are present can be considered as singenetic productive series. The process of oil and gas formation can proceed only in case reservoir beds are available in series under examination. The bitumens which are the products of dissociation of organic matter dispersed among mineral particles of pelite rocks may serve as geochemical property of singenetic productive series. Singenetic bitumens must be chemically kindred to bitumens dispersed in reservoir beds of the same series. The formation of oil and gas pools in these series can take place only under hydrochemical and hydrodynamic environment favourable for transition of hydrocarbons from a dispersed state into petroleum.

Dolomitic-limestone series can be considered as singenetic productive series only in case they include both bounded bitumens and asphaltites filling micropores and interstices, both substances being in close chemical affinity. It is also necessary to ascertain the process of dissociation of asphaltites with formation of hydrocarbons. Favourable hydrochemical and hydrodynamic conditions within dolomitic-limestone series are apparently required for transition of hydrocarbons from a dispersed state into petroleum.

The properties of the process of oil and gas formation in epigenetic productive series are entirely different. For the series, in which interbedding of reservoir rocks and poorly permeable

- 10 -

able rocks not generating bitumens is observed, it is required to prove the existence of relations with bitumen generating rocks of other series. These relations are possible first of all at the expense of lithological facial transition of the rocks formed in oxidising environment into bitumen generating rocks. Penetration of hydrocarbons into epigenetic productive series is possible also along the breaks or at the expense of squeezing from diapir or diapir-shape cores of anticlines. The transition of bitumens at the time of contact of reservoir rocks with bitumen generating rocks along the surface of angular unconformity is also not excluded.

In thick reservoir series constituting a unit massive reservoir, in the absence of a source of bitumen formation, the feeding by bitumens may take place either at the expense of underlying or mantling bitumen generating rocks or at lithological facial substitution by similar rocks. The feeding of epigenetic productive series may be ascertained by discovery of dispersed bitumens contained therein and chemically kindred to the bitumens of feeding rocks. The ways of bitumen migration can be determined as per processes of secondary reduction. Such secondary processes in red-coloured rocks are easily ascertained even visually owing to grayish-blue, greenish colouring of the rocks located on the way of migration of bituminous substances.

All the properties enumerated above are summarized in the enclosed table. The purpose of the table is to systematise only the principal data permitting to establish the processes of bitumen formation in the rocks and processes of oil and gas formation leading to formation of regionally productive series.

# DIAGNOSTIC OF THE PROCESSES OF FORMATION

Geol. study	Geological properties	
	Bitumen generating rocks	Rocks formed of subaqueous fine-grained both carbonate and non-carbonate sediments in the conditions of predominated downwarping.
Presence in the rocks of organic matter dispersed among mineral particles.		
Preservation of plastic property is required for terrigenous deposits, viz. such lithification intensity which admits the existence of subcapillary pores and semi-bounded water therein.		
Presence of free bitumens in the form of asphaltite filling fissures and vugs is required for lithified carbonate rocks (limestones and dolomites).		
Diagenetic productive series	Epigenetic productive series	For terrigenous and carbonate terrigenous deposits presence in their sequence of bitumen generating and reservoir rocks is required.
		Presence of communicating micro-and-macro interstices partly filled by asphaltites is required for dolomitic limestone series
Epigenetic productive series	Epigenetic productive series	For series characterized by interbedding of reservoir rocks with poorly permeable rocks not generating bitumens a relationship is required with bitumen producing rocks arising at the expense of litho-facial substitutions, structural complications (breaks, diapirs etc.) or at the expense of contact along the surface of angular unconformity.
		Feeding by bitumens at the expense of lithological facial substitution or from underlying and mantling bitumen generating rocks is required for thick reservoir rock series constituting natural massive reservoirs.

## **PROPERTIES**

### **BITUMENS, OIL AND GAS**

Compiled by I.O. Nred  
(October, 1958)

---

#### **Geochemical properties**

---

Reducing environment in the process of sedimentation and during subsequent transformations which determined gray, bluish, pale-bluish colouring of the rocks, sometimes with greenish or brownish tint.

Presence in organic matter of coaly and bituminous compounds usually with considerable prevalence of the first.

Metamorphism intensity of organic matter ensuring its subsequent dissociation with bitumen educing.

---

Presence of singenetic bitumens in poorly permeable rocks and chemically kindred bitumens dispersed in the rocks and dissolved in water contained in reservoir beds under hydrogeological environment favourable for transition of hydrocarbons from a dispersed state into petroleum.

Dissociation of asphaltites with formation of hydrocarbons under hydrogeological environment favourable for transition of hydrocarbons from a dispersed state into petroleum.

---

Presence of epigenetic bitumens chemically kindred to bitumens of feeding rocks and traces of secondary reduction on the way of bitumen migration.

---

Presence of epigenetic bitumens chemically kindred to bitumens of feeding rocks.

---